9. Sensors, Comunications, Control

UNDERSTANDING ITS/CVO TECHNOLOGY APPLICATIONS
Student Manual

MODULE 9 - SENSORS, COMMUNICATIONS, CONTROL

US Dept of Transportation

Learning Objectives

You will be able to:

- Identify ITS sensor, control, and communications technologies that can provide CVO benefits
- Understand some of the issues related to combining those technologies at the roadside

Module Structure

- Sensor technology (WIM, AVC, vehicle tracking loops)
- Control technology (decision algorithms)
- Communications technology (DSRC, satellites)
- Issues – putting the technologies together
- A concrete example: Midland's Scrunch Alley
- Questions & Recap

Sensor technology can identify potential safety or compliance problems

- Detect potential overweight vehicles to protect the highway infrastructure
- Detect possible braking or balance hazards
- Detect hazardous conditions for prompt treatment
- Observe traffic flow for traffic management

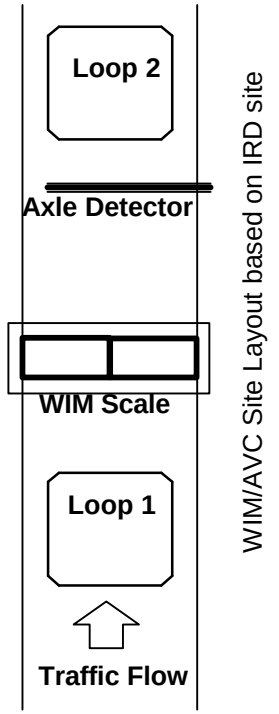
(Photo courtesy of Maryland State Highway Administration Statewide Operations Center)

Application of Sensor Technology

- Detect overweight vehicles
  - **Weigh In Motion (WIM)** measures axle loads
  - **Inductance loops and axle detectors** support Automatic Vehicle Classification (AVC)
- Assess braking and balance conditions
  - **Brake testing technology** can detect brake problems before they fail
  - **Weigh In Motion (WIM)** measures axle loads
  - **Axle detectors** can measure vehicle speed and length
- Detect hazardous conditions
  - **Road Surface and Weather sensors** can predict slippery conditions
- Observe traffic
  - **Video Monitoring** allows state traffic personnel to dispatch emergency and enforcement personnel or reroute traffic where needed

Automatic Vehicle Classification (AVC) combines several sensor types

- Axle Detectors
  - Count axles
  - Measure speed and length
- Inductance Loops
  - Detect physical vehicle
  - Determine which axles are part of one vehicle
- Weigh In Motion
  - Measure individual axle weights
  - Use axle count and spacing from other sensors to calculate gross weight and weigh distribution

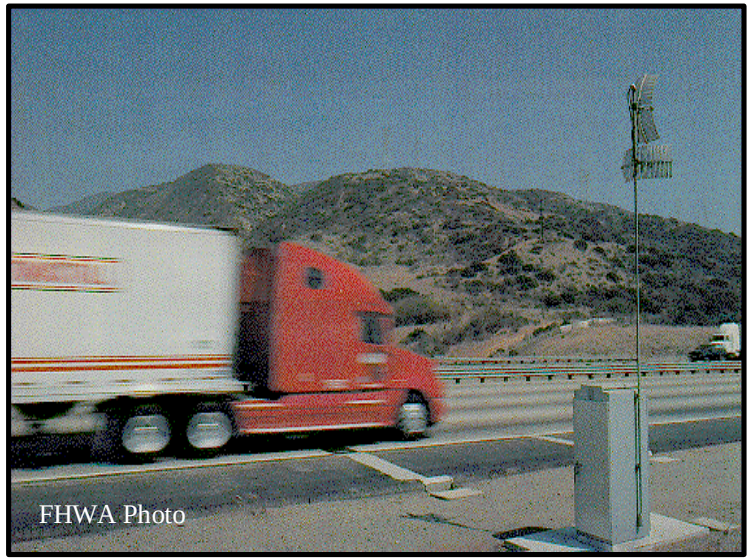


AVC Sensor Technology

- How axle detectors work
  - Pressure sensitive strips across the road
  - Detect change in resistance due to pressure
  - Paired sensors measure speed at each axle
  - Speed is used to measure distance between axles
- How loop detectors work
  - Wire loop on road surface detects the vehicle passing over the sensor area by measuring the change in inductance
  - Aids in measuring overall vehicle length, and in associating axle measurements with same vehicle

Weigh In Motion (WIM) has many applications

- Axle weights for balance and weight distribution
  (balance and braking safety)



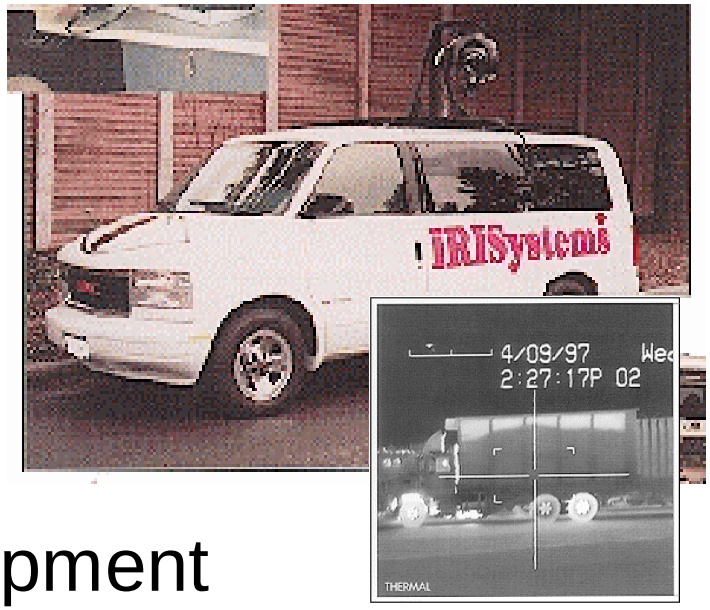
- Axle and gross weights for bridge safety restrictions
- Weight detection for screening to enhance the efficiency of enforcement
- Axle and gross weight data collection to assess road wear and tear for highway planning

WIM technologies

- Piezoelectric sensors
  - Low cost, low accuracy
  - May be built-in or taped down for mobile applications
- Bending Plate sensors
  - Medium cost and moderate accuracy
  - May be applied at ramp speeds or mainline
  - Fixed facility
- Load Cell sensors
  - High cost and accuracy
  - May be applied at ramp speeds or mainline
  - Fixed facility

Brake testing technology increases efficiency and accuracy

- Infrared detectors can predict brake problems
  - This permits faster screening of more vehicles
  - Sensors “see” things the inspector might miss



- Performance based testing equipment
  - Quantitatively measures actual braking capability
  - Previous test methods measured physical characteristics and assumed resulting capabilities

Brake Testing Concepts & Products

- Infrared Detectors for Brakes
  - Detect wheel bearing temperature when brakes are not applied to detect worn wheel bearings
  - Detect wheel drum temperature consistency when are applied to detect proper brake application
  - Additional information available from IRISystems
- Performance Based Brake Testing Technologies:
  - Roller Dynamometers
  - Flat Plate Testers
  - Breakaway Torque Testers
  - Infrared Brake Drum Measurement
  - On-Board Decelerometer

For more information, reference study by FHWA/OMC and Battelle Memorial Institute sited in the reference manual

Sensors can collect data on road surface and weather conditions

- Pavement Sensors
  - Pavement temperature
  - Pavement condition
  - Chemical content
  - Percentage of ice present
- Weather Towers
  - Air temperature
  - Wind speed
  - Wind direction
  - Visibility
  - Precipitation type

Surface & Weather Sensor Benefits

- Based on Accident studies in Maryland:
  - 30-35% of accidents occur when the road surface is not dry
  - 20-25% of accidents occur in inclement weather conditions such as rain, snow, sleet, and fog
- Current and accurate road surface and weather information can support prompt allocation of resources and traveler notification

Colorado employs a Downhill Truck Speed Advisory System

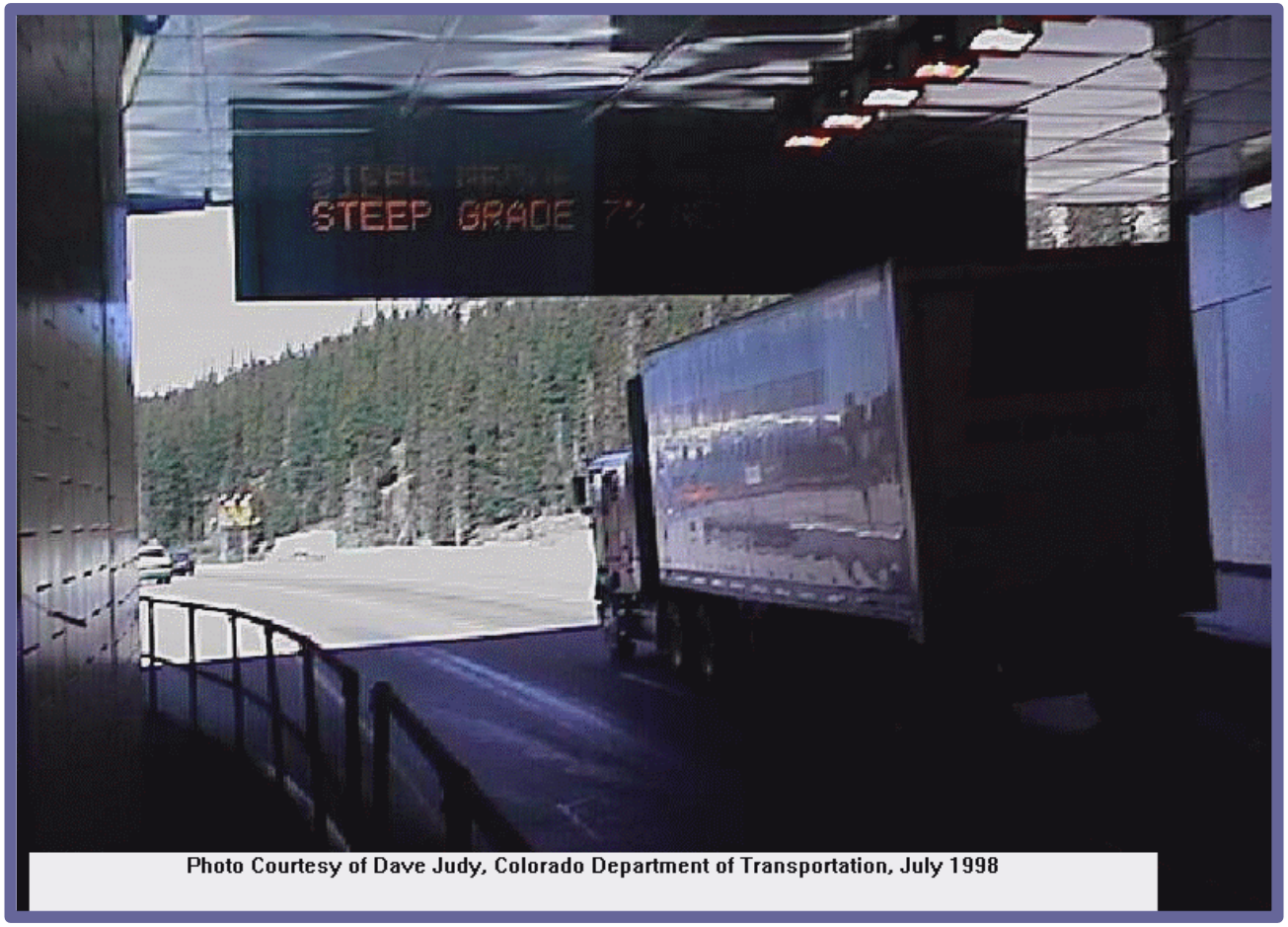


Photo Courtesy of Dave Judy, Colorado Department of Transportation, July 1998

Colorado's Downhill Truck Speed Advisory System

- Technical Approach:
  - Weigh In Motion is used to measure vehicle weight
  - System calculates safe speed based on weight for upcoming down-hill stretch
  - Driver is notified of safe speed by a Variable Message Sign
- System Effectiveness:
  - 13% reduction of accidents
  - 24% reduction of runaway ramp use.

Developed for the Colorado Department of Transportation

Statistics courtesy of International Road Dynamics

Maryland employs sensors for Roadside Weather Information Systems

Maryland's Roadside Weather Information Systems

- Technical Approach:
  - 51 sites statewide consisting of pavement sensors and weather towers
  - Sensor data includes: pavement temperature, condition, chemical content, ice percentage
  - Weather tower data includes: air temperature, wind speed and direction, visibility, precipitation type
  - Sensor / weather data is used for more accurate call-outs, operation planning and material management

The Roadside Weather Information Systems (RWIS) are part of the Maryland State Highway Administration's Chesapeake Highways Advisories Routing Traffic (CHART) program

ITS/CVO Algorithms assist in decision making processes

- Roadside Electronic Screening (See Module 11)
  - Weight
    - Weigh In Motion
- Safety
  - SAFESTAT
  - Inspection Selection System (ISS)
- Credentials
  - IRP
  - IFTA
  - etc.

Other ITS algorithms

- Calculate recommended safe speed for current road conditions or grade based on measured weight, length, and distribution
- Calculate actual vehicle speed
- Automate traffic information systems

Communications technology brings solutions right to the drivers

- Provide general information to all traffic
  - **Variable Message Signs**
  - **Highway Advisory Radio**
- Communicate to individual vehicles
  - **Variable Message Signs**
  - **Dedicated Short Range Communications (DSRC)**

(Photo courtesy of Maryland State Highway Administration)

Communications Applications

- General information:
  - Weather or road conditions
  - Traffic congestion
  - Construction status
- Status or instructions for each vehicle:
  - Result of electronic screening decision
  - Measured vehicle speed
  - Speed or braking recommendations based on weight
  - Lane to follow, based on vehicle class or level of traffic

Communications technology can provide centralized control

- Control overall traffic flow or routing
  - **Traffic gates**
  - **Lane signals**
- Relay information to central location
  - **Satellite communications**
  - **Telephone or network communications**

The Virginia Highwayman

Communications Applications

- Control traffic flow or routing
  - Variable lane usage for commuter hours
  - Construction re-routing
- Relay information to central location
  - Relay road surface conditions to dispatch equipment
  - Relay video images for traffic reporting

Intelligent Messages Improve Traffic Safety and Efficiency

- Variable Message Signs….
  … may have fixed message supplied from a remote location
  … may be controlled for each vehicle by in-road sensors and control algorithm
- Communicating to On-Board Devices….
  … such as on-board navigation systems
  … or on-board traveler information systems
  can provide valuable information to the driver
- Dedicated Short Range Communications…
  … is currently applied to toll and screening applications
  … can support other dedicated communications to in-cab unit
- Network Communications to the Roadside…
  … is becoming more commonly available
  … can support a variety of applications

Communications Technologies

- Dedicated Short Range Communications (DSRC):

  Provides data communications between roadside equipment and a specific moving vehicle by means of a radio frequency transponder located in the cab of the vehicle. The transponder may contain identification, and possibly additional data. DSRC can support electronic screening, electronic tolls, fleet management, and other roadside communications. Hardware and communications standards are under development by ASTM (E17.51). IEEE is establishing message set standards (P1455).

- Roadside Network Technologies

  Roadside applications can communicate with a central location through a variety of network types:

  - Fiber optic networks -- high speed, can support many functions
  - Automatic direct dial-up modems -- low cost, existing infrastructure
  - Modem access to a value-added network -- moderate costs, provides data services

Consider alternatives when selecting technologies

- Cost vs. Quality
  - Select WIM technology for best accuracy or lowest cost
- Durability
  - May need to weigh cost against durability for WIM
  - Consider road, weather, and equipment when selecting road sensors
- Effectiveness
  - DSRC can provide in-cab signals to a specific vehicle, but roadside message signs can reach everyone

Technology Alternatives

- Other alternatives to consider….

  Students use this space to record personal ideas and results of classroom discussion:

System Integration is **key** to putting the technologies together

- Coordinate sensors and software for AVC and DSRC
  - Timing considerations
  - Relative placement in pavement
  - Durability
- Consider road use and conditions when selecting sensors
  - How heavy is the traffic over the sensors?
  - What weather and equipment conditions exist?

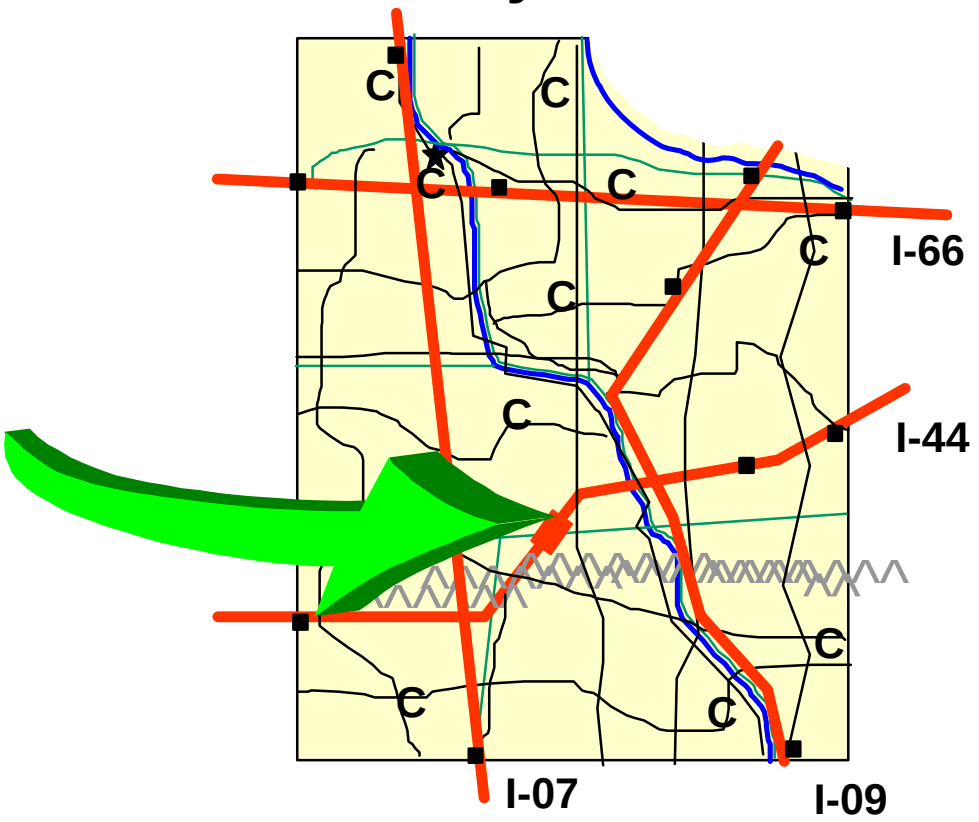
Putting the technologies together

- To insure smooth and reliable system integration, it is very important that the system integrators be familiar with the technologies and the integration issues involved. Textbook solutions may not apply in situations where moving traffic and weather conditions are involved. Be sure to have someone within the state or lead organization who understands the issues so that problems can be detected and resolved early.

- In addition to system integration,*system maintenance* must also be considered.

Scrunch Alley in Midland - The problems

- **20% of all Commercial Vehicle crashes occur on one 20 mile stretch, known as “Scrunch Alley”**



Scrunch Alley in Midland - The problems

Scrunch Alley

A recently completed study provides new insight about the patterns of crashes in Scrunch Alley:

- Many crashes involve trucks with poorly-balanced loads (65%)
- Many crashes occur during the first few hours of precipitation just after a long dry spell (30%)

Since so many crashes occur in this short stretch of road, Midland hopes to be able to focus efforts here to significantly improve the state-wide crash figures.

Brainstorm

- What technologies might help Scrunch Alley?

Brainstorming Tips

- Remember to -
  - Identify the problem (sensors)
  - Identify the solutions (algorithms)
  - Communicate the solution (communications)
- Consider alternatives and integration issues
- What problems do you want to solve?
- What problems can you solve?

Recap & Questions

The objectives . . .

- Identify sensor, control, and communications technologies used in ITS/CVO
- Understand some of the issues related to combining those technologies at the roadside

Any questions?